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(54) **THREE-DIMENSIONAL DISPLAY SYSTEM**

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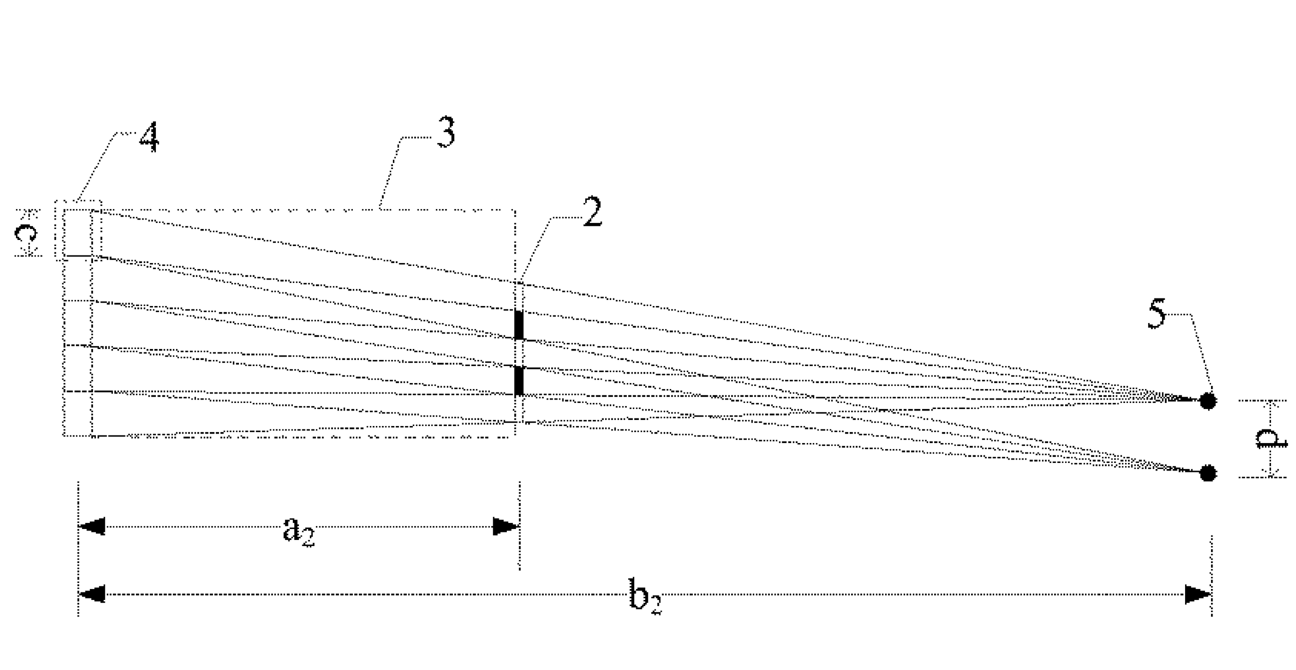
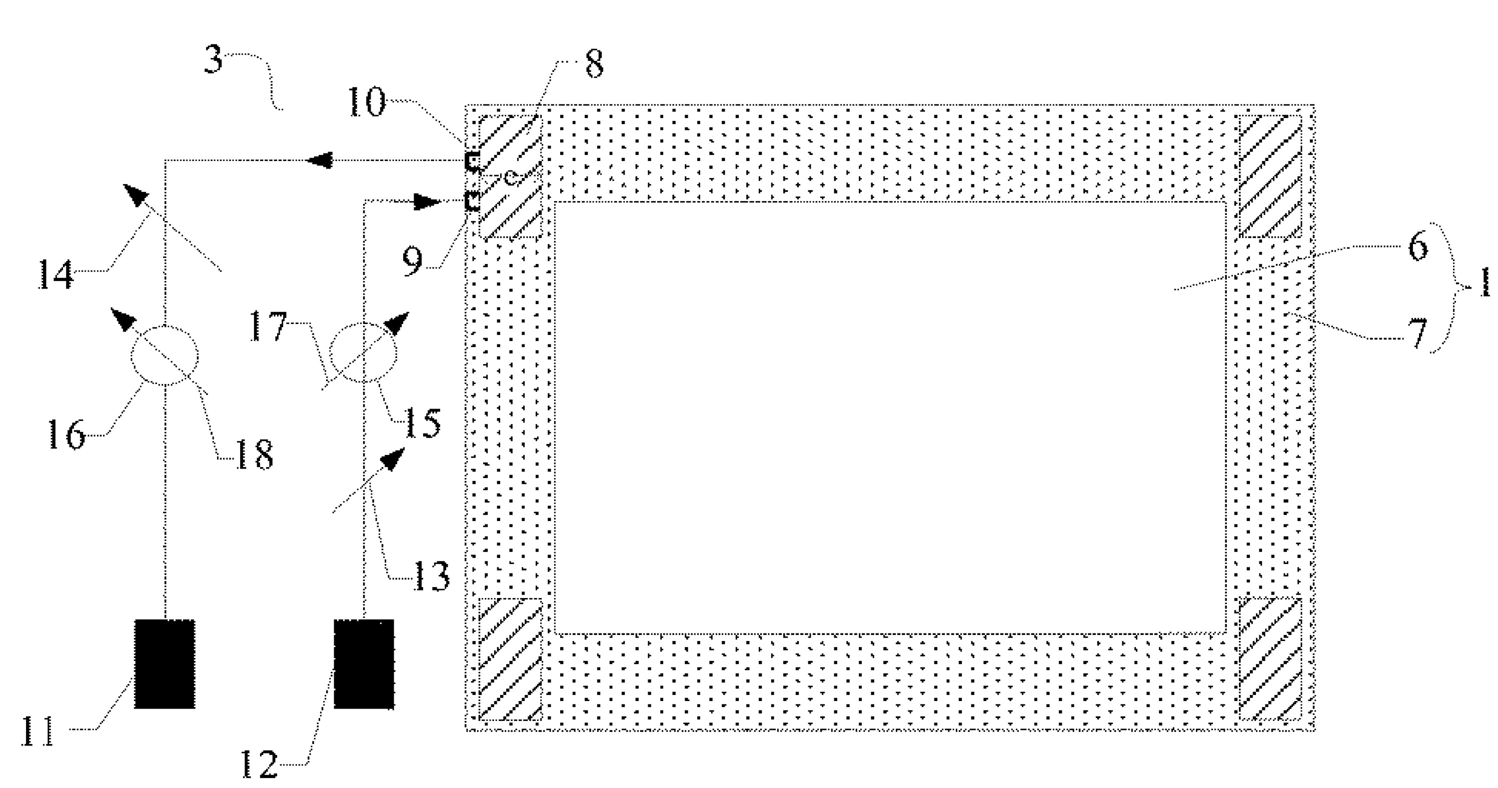
(57) **ABSTRACT**

The present disclosure discloses a three-dimensional display system, comprising a display device and a barrier located at the light emergent side of the display device. Addition of the distance adjusting structure, which adjusts the viewing distance of the three-dimensional display system by adjusting the distance between the display device and the barrier, between the display device and the barrier allows the three-dimensional display system free from limitation of a fixed viewing distance, thus resulting in a stronger spatially adapting capability and a broader application scope thereof.

10 Claims, 3 Drawing Sheets





(58) **Field of Classification Search**
USPC 359/462, 476, 477; 348/42, 51; 345/419; 349/15
See application file for complete search history.

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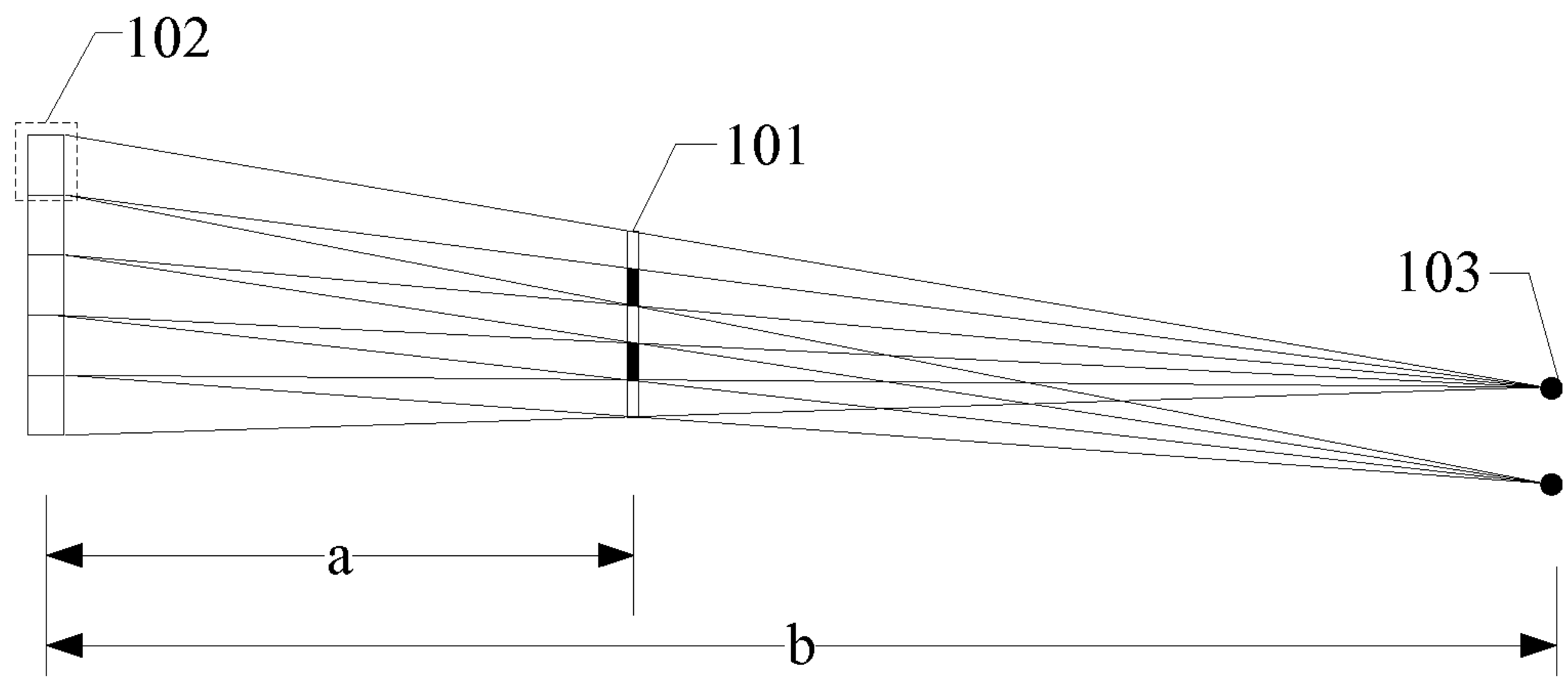

Fig. 1

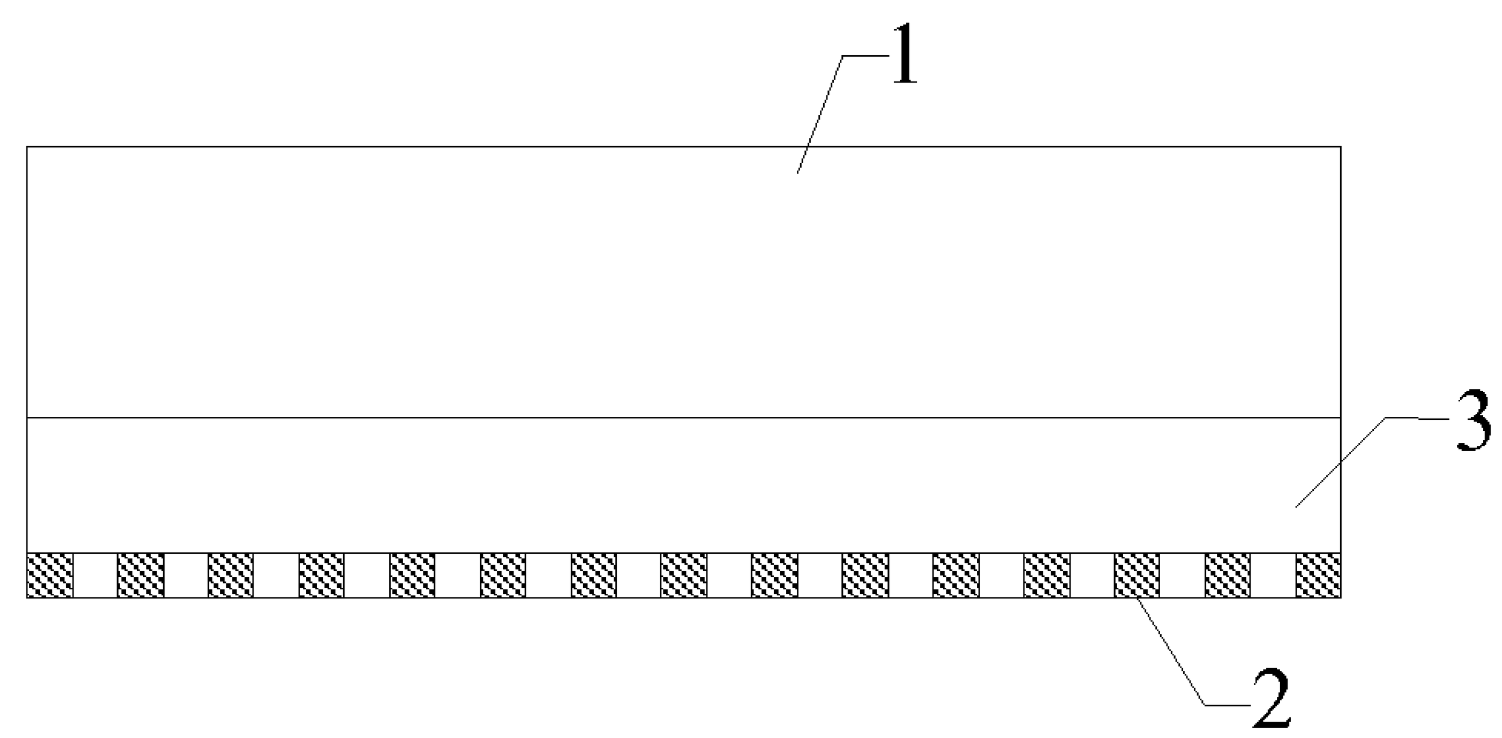

Fig. 2

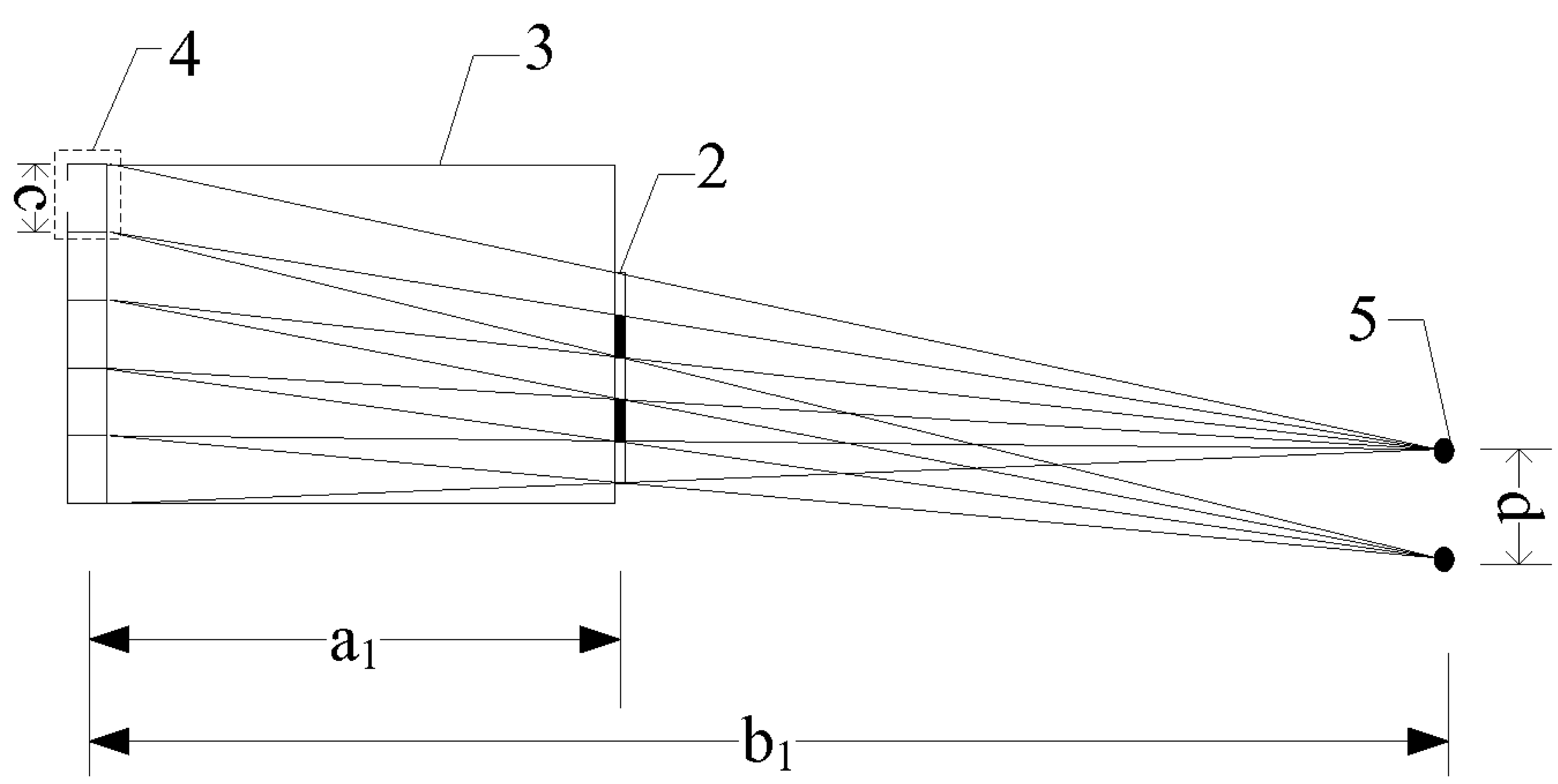

Fig. 3a

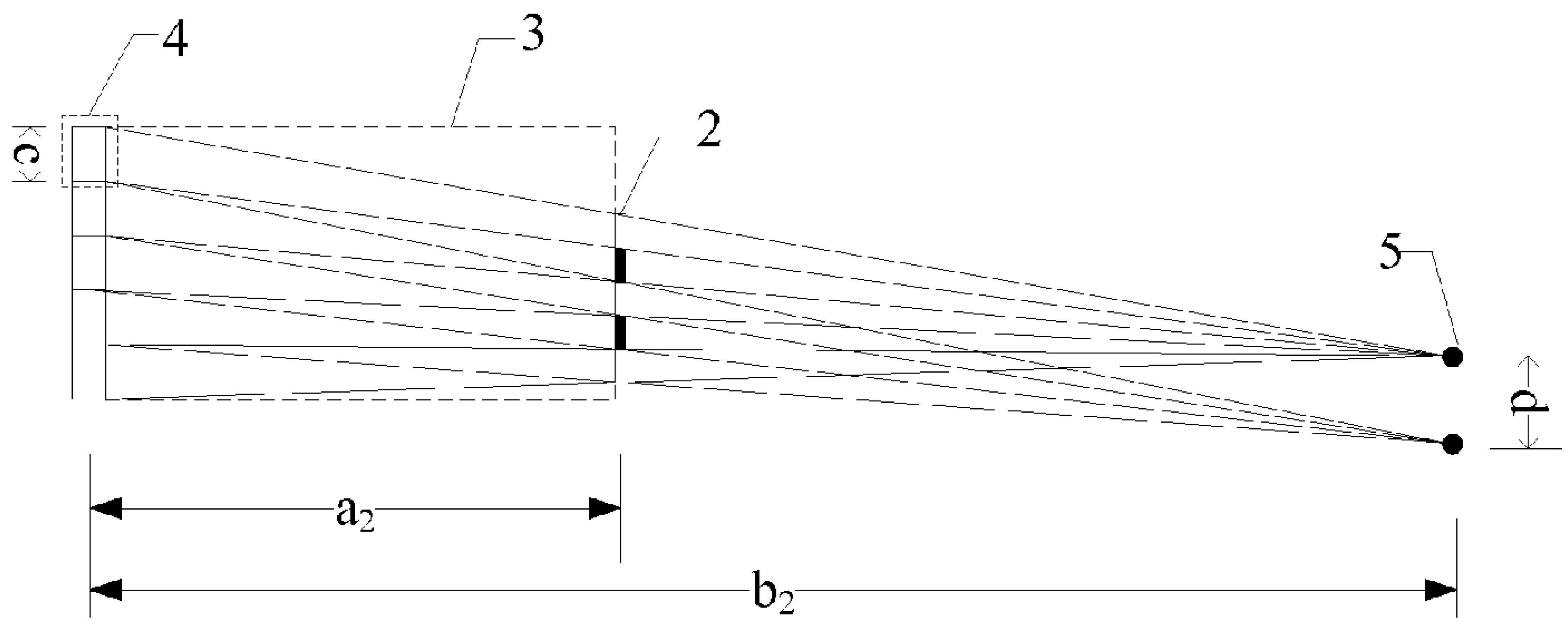

Fig. 3b

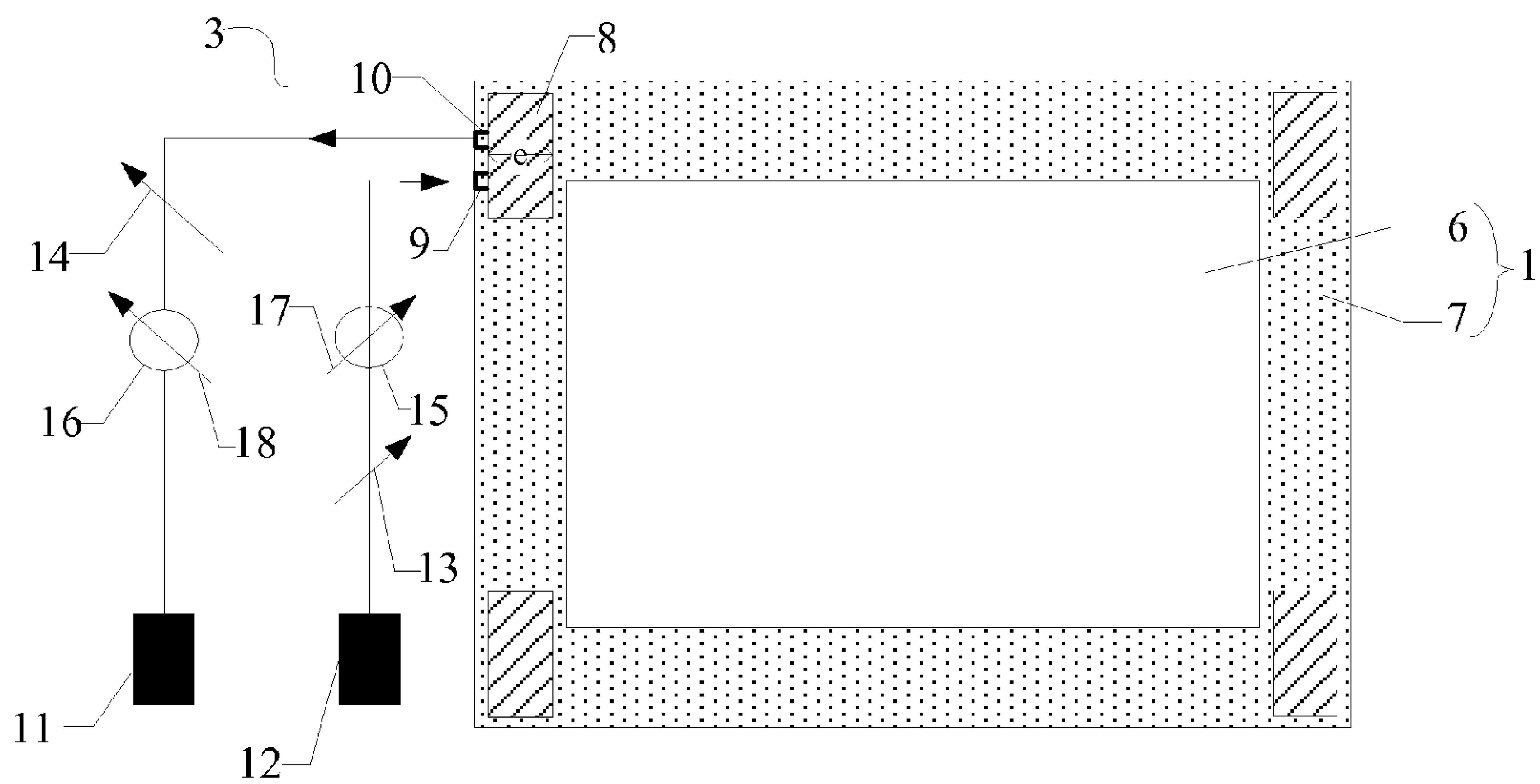

Fig. 4a

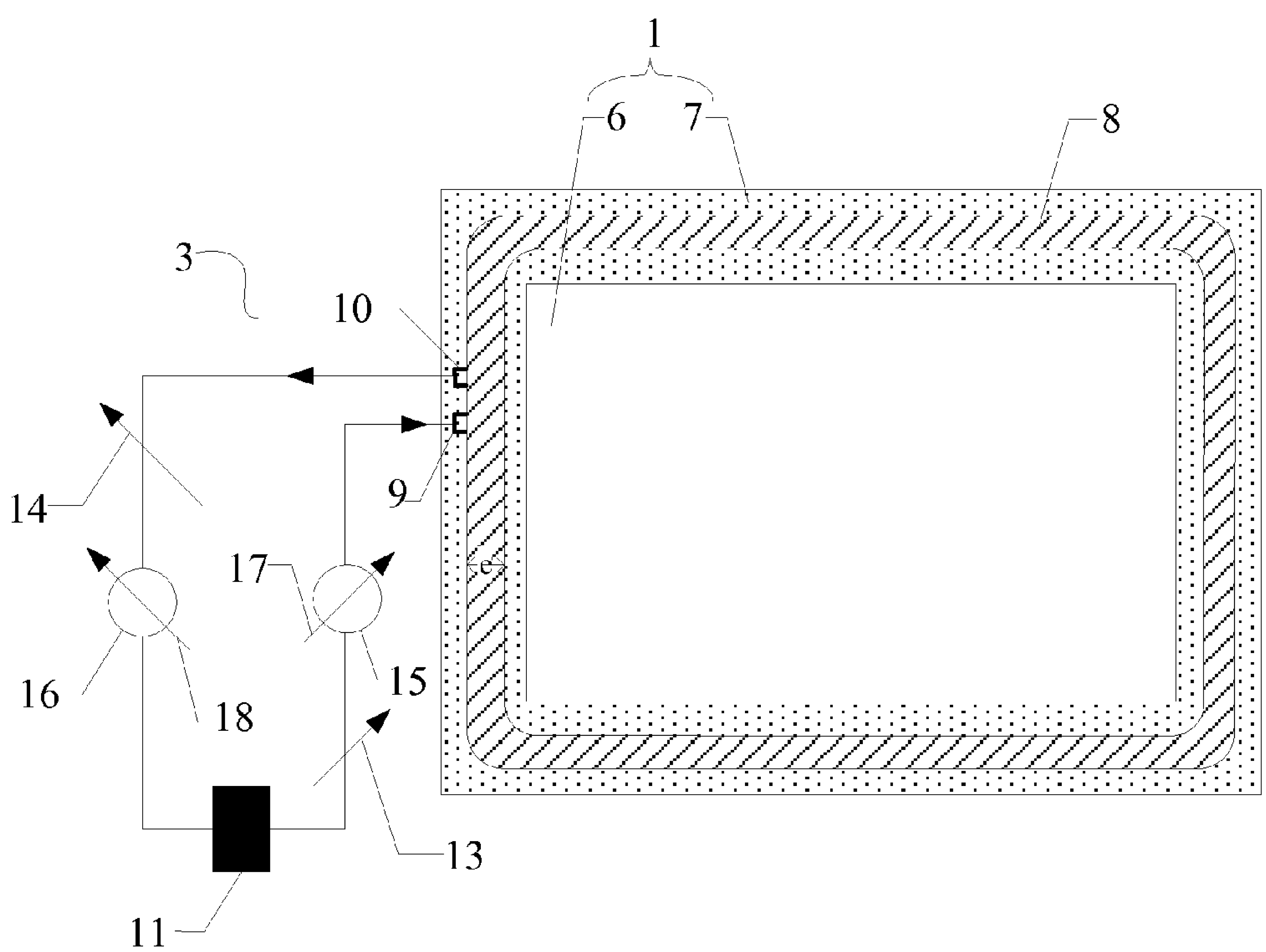

Fig. 4b

THREE-DIMENSIONAL DISPLAY SYSTEM

The present patent application is a national phase application of International Application No. PCT/CN2014/083422, filed Jul. 31, 2014.

FIELD OF DISCLOSURE

The present disclosure relates to the field of display technology, particularly to a three-dimensional display system.

BACKGROUND

At present, the three-dimensional (3D) display technology has received great attention, which can render a picture stereoscopic and thus vivid, based on the basic principle that with the left and right eyes receiving different pictures, respectively, the human brain overlaps and reproduces the received image information to construct a stereoscopic image.

An existing important display apparatus capable of realizing 3D display provides a shelter, such as a slit barrier or a liquid crystal barrier, on the light emergent side of the display panel, with the slit barrier or the liquid crystal barrier forming several fields of view on the light emergent side of the display panel. As shown in FIG. **1**, taking the display panel provided with a slit barrier **101** on the light emergent side as an example, with the light emitted by different sub-pixel units **102** (taking 5 different sub-pixel units as an example in FIG. **1**) on the display panel shining on different fields of view, a 3D effect may be created when the two eyes **103** of the viewer fall in different fields of view. As shown in FIG. **1**, a is the distance between the sub-pixel unit **102** on the display panel and the slit barrier **101**, and b is the viewing distance of the display apparatus, i.e. the distance between the sub-pixel unit **102** on the display panel and the two eyes **103** of the viewer.

In the existing 3D display technology, the viewing distance b at which the viewer views the display panel is fixed, due to a fixed distance a between the slit barrier or the liquid crystal barrier and the display panel. When the viewer views the display panel at a distance other than the viewing distance b, a crosstalk which affects the 3D display effect will be produced, thus greatly limiting the application scope of the 3D display.

Therefore, how to prevent the 3D display from limitation of a fixed viewing distance is an urgent technical problem to be addressed by the skilled in the art.

SUMMARY OF THE DISCLOSURE

In view of this, an embodiment of the present disclosure provides a three-dimensional display system to prevent the 3D display from limitation of a fixed viewing distance.

Thus, an embodiment of the present disclosure provides a three-dimensional display system, comprising a display device and a barrier located at the light emergent side of the display device; further comprising a distance adjusting structure arranged between the display device and the barrier, the distance adjusting structure being used to adjust the viewing distance of the three-dimensional display system by adjusting the distance between the display device and the barrier.

In the three-dimensional display system provided by the embodiment of the disclosure, addition of the distance adjusting structure, which adjusts the viewing distance of

the three-dimensional display system by adjusting the distance between the display device and the barrier, between the display device and the barrier allows the three-dimensional display system free from limitation of a fixed viewing distance, thus resulting in a stronger spatially adapting capability and a broader application scope thereof.

Specifically, in the three-dimensional display system provided by the embodiment of the disclosure, the display device consists of a display region and a boundary-closed non-display region encompassing the display region.

The distance adjusting structure comprises at least one hollow cavity arranged at the non-display region, the volume of the hollow cavity being made increased or decreased accordingly by inputting or outputting gas or liquid to/from the hollow cavity.

Preferably, in order to keep the barrier as a whole in parallel to the display device when moving with respect to the display device, in the three-dimensional display system provided by the embodiment of the disclosure, the hollow cavity is a loop cavity.

Optionally, the at least one hollow cavity is multiple ones which are arranged uniformly or non-uniformly at the non-display region.

Further, in the three-dimensional display system provided by the embodiment of the disclosure, the distance adjusting structure further comprises:

at least one pair of an inlet and an outlet arranged on the wall of the hollow cavity, an input pressure pump connected with the inlet, an output pressure pump connected with the outlet, an input valve arranged between the inlet and the input pressure pump, and an output valve arranged between the outlet and the output pressure pump.

Specifically, the input pressure pump and the output pressure pump are integrated into one pressure pump, or are two separate pressure pumps.

Preferably, in the three-dimensional display system provided by the embodiment of the disclosure, the input pressure pump and the output pressure pump are of pneumatic type or of hydraulic type.

Further, in the case that the input pressure pump and the output pressure pump are two separate pressure pumps, the input pressure pump and the output pressure pump are of the same or different type.

Preferably, in order for a uniform throughput of the gas or liquid to/from the hollow cavity to ensure a parallel display device with respect to the barrier, and thus the display effect of the three-dimensional display system, in the three-dimensional display system provided by the embodiment of the disclosure, in the hollow cavity, every two neighboring pairs of the inlets and the outlets are equally spaced.

Further, in order for a precise control of the variation in the volume of the hollow cavity, and thus a precise adjustment of the distance between the display device and the barrier, so as to precisely adjust the viewing distance of the three-dimensional display system, in the three-dimensional display system provided by the embodiment of the disclosure, the distance adjusting structure further comprises: a first flow controller arranged between the inlet and the input valve or between the input valve and the input pressure pump; and a second flow controller arranged between the outlet and the output valve or between the output valve and the output pressure pump.

Optionally, the area of the cross section of the hollow cavity at different depths in the depth direction of the display is constant or non-constant, the depth direction being the direction perpendicular to the display plane of the display.

Optionally, the amount of increase or decrease in the volume of the hollow cavity is calculated in real time or obtained by looking up a lookup table.

Specifically, in the three-dimensional display system provided by the embodiment of the disclosure, the barrier is a slit barrier or a liquid crystal barrier.

Specifically, in the three-dimensional display system provided by the embodiment of the disclosure, the display device is a liquid crystal display device or an organic electroluminescence display device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of the light path of a three-dimensional display apparatus in the prior art;

FIG. **2** is a schematic diagram of the structural side view of the three-dimensional display system provided by an embodiment of the disclosure;

FIGS. **3***a* and **3***b* are the light path of the three-dimensional display system provided by an embodiment of the disclosure before and after the viewing distance adjustment, respectively;

FIGS. **4***a* and **4***b* are a schematic diagram of the structural plan view of the three-dimensional display system provided by embodiments of the disclosure, respectively.

DETAILED DESCRIPTION

The three-dimensional display system provided by embodiments of the disclosure is described below in detail, with reference to the appended drawings.

A three-dimensional display system provided by an embodiment of the present disclosure, as shown in FIG. **2**, comprising: a display device **1**, and a barrier **2** located at the light emergent side of the display device **1**; further comprising: a distance adjusting structure **3** arranged between the display device **1** and the barrier **2**, the distance adjusting structure **3** being used to adjust the viewing distance of the three-dimensional display system by adjusting the distance between the display device **1** and the barrier **2**.

In the three-dimensional display system provided by the embodiment of the disclosure, addition of the distance adjusting structure **3**, which adjusts the viewing distance of the three-dimensional display system by adjusting the distance between the display device **1** and the barrier **2**, between the display device **1** and the barrier **2** allows the three-dimensional display system free from limitation of a fixed viewing distance, thus resulting in a stronger spatially adapting capability and a broader application scope thereof.

FIGS. **3***a* and **3***b* are the light path of the three-dimensional display system provided by an embodiment of the disclosure before and after the viewing distance adjustment, respectively. As shown in FIG. **3***a*, the distance between the individual sub-pixel units **4** in the display device **1** and the barrier **2** is a_1, and the viewing distance of the three-dimensional display system, i.e. the distance between the individual sub-pixel units **4** in the display device **1** and the two eyes **5** of the viewer is b_1. As shown in FIG. **3***b*, after adjustment of the distance adjusting structure **3**, the distance between the individual sub-pixel units **4** in the display device **1** and the barrier **2** turns to a_2, and the viewing distance of the three-dimensional display system, i.e. the distance between the individual sub-pixel units **4** in the display device **1** and the two eyes **5** of the viewer turns to b_2. Thus, through the adjustment by the distance adjusting structure **3**, the variation in the distance between the individual sub-pixel units **4** in the display device **1** and the

barrier **2** is $\Delta a=a_2-a_1$, and the variation in the viewing distance of the three-dimensional display system is $\Delta b=b_2-b_1$.

Specifically, while the distance between the individual sub-pixel units **4** in the display device **1** and the barrier **2** varies by Δa, the viewing distance of the three-dimensional display system varies by Δb accordingly. The relationship between the variation Δa of the distance between the individual sub-pixel units **4** in the display device **1** and the barrier **2** and the variation Δb of the viewing distance of the three-dimensional display system is

$$\frac{\Delta a}{\Delta b}=\frac{a_1}{b_1}=\frac{a_2}{b_2}=\frac{c}{c+d},$$

where c is the width of the sub-pixel unit **4**, and d is the distance between the eyes **5** of the viewer. For example, with the width c of the sub-pixel unit **4** being 90 μm and the distance d between the eyes **5** of the viewer being 5 cm, if the viewing distance of the three-dimensional display system needs to be increased by 1 in (i.e. Δb=1 m), then it can be calculated that the distance between the individual sub-pixel units **4** in the display device **1** and the barrier **2** needs to be increased by about 1.8 mm.

Specifically, in an implementation of the three-dimensional display system provided by the embodiment of the disclosure, as shown in FIGS. **4***a* and **4***b*, the display device **1** may consist of a display region **6** and a boundary-closed non-display region **7** encompassing the display region **6**. The distance adjusting structure **3** may specifically comprise at least one hollow cavity **8** arranged at the non-display region **7**, the volume of the hollow cavity **8** being made increased or decreased accordingly by inputting or outputting gas or liquid to/from the hollow cavity **8**, such that the distance between the display device **1** and the barrier **2** (not shown in FIGS. **4***a* and **4***b*) may be changed, and, in turn, an adjustable viewing distance of the three-dimensional display system can be achieved.

FIG. **4***a* illustrates a display device **1** provided with four hollow cavities **8** in the non-display region **7**. In order to ensure a parallel display device **1** with respect to the barrier **2**, and thus the display effect of the three-dimensional display system, multiple hollow cavities **8** may be uniformly arranged at the non-display region **7** of the display device **1**. FIG. **4***a* illustrates four hollow cavities **8** arranged, respectively, at the four corners of the non-display region **7** of the display device **1**. Of course, the number of the hollow cavities **8** as shown in FIG. **4***a* is not limited to 4. Moreover, the way in which the hollow cavities **8** are distributed may be other forms, such as in a non-uniform way, which is not limited here.

Preferably, in order to keep the barrier **2** as a whole in parallel to the display device **1** when moving with respect to the display device **1**, in an implementation of the three-dimensional display system provided by the embodiment of the disclosure, as shown in FIG. **4***b*, the distance adjusting structure **3** may comprise only one hollow cavity **8**, which is a loop cavity that encompasses the display region **6**.

Specifically, in the distance adjusting structure **3** as shown in FIGS. **4***a* and **4***b*, the width e of the projection of the hollow cavity **8** on the non-display region **7** of the display device **1** is generally set to be larger than 0 mm and smaller than or equal to 25 mm.

In an embodiment of the disclosure, assuming that the area of the cross section of the hollow cavity **8** is constant at different depths in the depth direction of the display device **1** (i.e. the direction perpendicular to the display plane of the display device **1**), in the case that the viewing distance of the three-dimensional display system needs to be adjusted by Δb and the distance between the individual sub-pixel units **4** in the display device **1** and the barrier **2** needs to be adjusted by Δa, then the volume of the hollow cavity **8** needs to be changed by

$$\Delta V = \Delta a * S = \frac{c}{c+d} * \Delta b * S,$$

where S is the area of the cross section of the hollow cavity **8**. For example, the area of the cross section of the hollow cavity **8** being 100 mm^2, if the viewing distance of the three-dimensional display system needs to be increased by 1 in and the distance between the display device **1** and the barrier **2** needs to be increased by 1.8 mm, then the volume of the hollow cavity **8** needs to be changed by 0.18 mL.

It should be understood by the skilled in the art that in other embodiments of the disclosure, the area of the cross section of the hollow cavity **8** may not be constant at different depths in the depth direction of the display device **1**. In this case, the required variation in the volume of the hollow cavity **8** may be calculated in real time for a viewing distance adjustment. For example, depending on the shape and area of the cross section of the hollow cavity **8**, the required variation in the volume of the hollow cavity **8** may be calculated in real time, utilizing the viewing distance adjustment value Δb required for the three-dimensional display system, as well as the relationship between the viewing distance adjustment value Δb and the variation Δa in the distance between the individual sub-pixel units **4** in the display device **1** and the barrier **2**. Thereby, the input/output pressure pump is controlled to input/output the gas or liquid to achieve a viewing distance adjustment of the three-dimensional display system. Alternatively, in order to reduce the computation overhead and to improve the processing speed of the system, the required variation in the volume of the hollow cavity **8** may also be obtained by looking up a Look Up Table (LUT). For example, the correspondence among the current viewing distance of the three-dimensional system, the required viewing distance adjustment value Δb and the variation in the volume of the hollow cavity **8** being stored in advance in a memory as a LUT, in adjusting the viewing distance, the required variation in the volume of the hollow cavity **8** corresponding to the required viewing distance adjustment value Δb may be obtained under the current viewing distance by looking up the LUT, and in turn the input/output pressure pump may be controlled accordingly to input/output the gas or liquid.

Specifically, in an implementation of the three-dimensional display system provided by the embodiment of the disclosure, as shown in FIG. **4***a*, the distance adjusting structure **3** may further comprise at least one pair of an inlet **9** and an outlet **10** arranged on the wall of the hollow cavity **8**, an input pressure pump **11** connected with the inlet **9**, an output pressure pump **12** connected with the outlet **10**, an input valve **13** arranged between the inlet **9** and the input pressure pump **11**, and an output valve **14** arranged between the outlet **10** and the output pressure pump **12**. When the input valve **13** is opened, the input pressure pump **11** pumps the gas or liquid into the hollow cavity **8**, and when the output valve **14** is opened, the output pressure pump **12** pumps the gas or liquid out of the hollow cavity **8**. While FIG. **4***a* illustrates only one hollow cavity **8** connecting to an input pressure pump **11** and an output pressure pump **12**, the other three hollow cavities **8** each are connected to a respective input pressure pump **11** and a respective output pressure pump **12** in a similar manner, which is not discussed in detail.

When the three-dimensional display system provided by the embodiment of the disclosure is used for normal 3D display, i.e. the viewing distance of the three-dimensional display system provided by the embodiment of the disclosure needs not to be adjusted, the input valve **13** and the output valve **14** are in a closed state, the distance between the display device **1** and the barrier **2** is fixed, and the viewing distance of the three-dimensional display system is fixed, ensuring a display effect of the three-dimensional display system. When the viewing distance of the three-dimensional display system provided by the embodiment of the disclosure needs to be increased, the input valve **13** is in a open state, and the output valve **14** is in the closed state, then the input pressure pump **11** pumps the gas or liquid into the hollow cavity **8** such that the distance between the display device **1** and the barrier **2** is increased, thus resulting in an increased viewing distance of the three-dimensional display system. When the viewing distance of the three-dimensional display system provided by the embodiment of the disclosure needs to be decreased, the input valve **13** is in the closed state, and the output valve **14** is in the open state, then the output pressure pump **12** pumps the gas or liquid out of the hollow cavity **8** such that the distance between the display device **1** and the barrier **2** is decreased, thus resulting in a decreased viewing distance of the three-dimensional display system.

In an implementation of the three-dimensional display system provided by the embodiment of the disclosure, as shown in FIG. **4***a*, the input pressure pump **11** and the output pressure pump **12** may be separate and arranged to be connected to the inlet **9** and the outlet **10**, respectively. Alternatively, as shown in FIG. **4***b*, the input pressure pump **11** and the output pressure pump **12** may be integrated into one pressure pump (illustrated as the input pressure pump **11** in FIG. **4***b*), with the inlet **9** and the outlet **10** connected thereto, so as to save the production cost.

Preferably, in an implementation of the three-dimensional display system provided by the embodiment of the disclosure, sufficient inlets **9** and outlets **10** may be arranged on the wall of the hollow cavity **8**, especially for the three-dimensional display system of larger size. In this way, it is ensured that the gas or liquid can be uniformly pumped into/out of the hollow cavity **8** and the display device **1** is parallel to the barrier **2**, such that the display effect of the three-dimensional display system is guaranteed. For example, in the four hollow cavities **8** as shown in FIG. **4***a*, one or more pairs of the inlets **9** and the outlets **10** may be arranged on the wall of each of the hollow cavities **8**, respectively; in the hollow cavity **8** as shown in FIG. **4***b*, one or more pairs of the inlets **9** and the outlets **10** may be arranged on the wall of each of the four sides of the hollow cavity **8**, respectively.

To further enable the gas or liquid to be pumped uniformly into/out of the hollow cavity **8**, which results in a parallel display device **1** with respect to the barrier **2** and thus a desired display effect of the three-dimensional display system, in a certain hollow cavity **8** of the three-dimensional display system provided by the embodiment of the disclosure (i.e. any of the hollow cavities **8** as shown in FIG. **4***a*, or the loop hollow cavity **8** as shown in FIG. **4***b*), every neighboring two pairs of the inlets **9** and the outlets **10** may be equally spaced, i.e. each pair of the inlet **9** and the output **10** is arranged uniformly on the wall of the hollow cavity **8**.

Specifically, in an implementation of the three-dimensional display system provided by the embodiment of the disclosure, the input pressure pump **11** and the output pressure pump **12** may be of pneumatic type or of hydraulic type. Moreover, in the case that the input pressure pump **11** and the output pressure pump **12** are two separate pressure pumps, they may be of the same or different type. By means of the pneumatic pump or the hydraulic pump pumping the gas or liquid into/out of the hollow cavity **8**, the distance between the barrier **2** and the display device **1** can be adjusted, thus achieving an adjustable viewing distance of the three-dimensional display system.

Specifically, the gas inside the pneumatic pump may be any gas that is stable and safe, and the hydraulic pump may be an oil hydraulic pump or a water hydraulic pump.

Of course, in an implementation of the three-dimensional display system provided by the embodiment of the disclosure, inside the input pressure pump **11** and the output pressure pump **12** may be other substances that are of good liquidity.

Further, in order for a precise control of the variation in the volume of the hollow cavity **8**, and thus a precise adjustment of the distance between the display device **1** and the barrier **2**, so as to precisely adjust the viewing distance of the three-dimensional display system, in the three-dimensional display system provided by the embodiment of the disclosure, the distance adjusting structure **3** further comprises: a first flow controller **15** arranged between the inlet **9** the input pressure pump **12**; and a second flow controller **16** arranged between the outlet **10** and the output pressure pump **11**. The first flow controller **15** may specifically be arranged between the inlet **9** and the input valve **13**, or arranged between the input valve **13** and the input pressure pump **12**. A first flow controlling valve **17** may be arranged inside the first flow controller **15** for controlling the flow of the gas or liquid that is pumped into the hollow cavity **8**. The second flow controller **16** may specifically be arranged between the outlet **10** and the output valve **14**, or arranged between the output valve **14** and the output pressure pump **11**. A second flow controlling valve **18** may be arranged inside the second flow controller **16** for controlling the flow of the gas or liquid that is pumped out of the hollow cavity **8**. Depending on the type of the liquid, various common gas flow controlling valves or liquid flow controlling valves may be employed as the first flow controlling valve **17** and the second flow controlling valve **18**. It is to be noted that illustrations are made here taking the input pressure pump **11** and the output pressure pump **12** being separate as an example, as described above however, the input pressure pump **11** and the output pump **12** may be integrated into one pressure pump.

Specifically, in the three-dimensional display system provided by the embodiment of the disclosure, the barrier **2** may be a slit barrier or a liquid crystal barrier. Moreover, the slit barrier and the liquid crystal barrier may be implemented in various ways which are not discussed here in detail. By means of the distance adjusting structure **3** adjusting the distance between the barrier **2** and the display device **1**, an adjustable viewing distance of the three-dimensional display system may be achieved.

The three-dimensional display system provided by the embodiment of the disclosure has been illustrated using a slit barrier as the barrier **2**, and the implementations using a liquid crystal barrier as the barrier **2** may refer to the embodiments using the slit barrier as the barrier **2**, which are not discussed here in detail.

Specifically, in the three-dimensional display system provided by the embodiment of the disclosure, the display device **1** may be a liquid crystal display device or a organic electroluminescence display device. Moreover, the liquid crystal display device or organic electroluminescence display device may be of various structures that are not discussed here in detail. By means of the distance adjusting structure **3** adjusting the distance between the barrier **2** and the display device **1**, an adjustable viewing distance of the three-dimensional display system may be achieved.

Furthermore, in the case that the display device **1** in the three-dimensional display system provided by the embodiment of the disclosure is a liquid crystal display device, it may specifically be of Advanced Super Dimension Switch (ASDS) type, of Twisted Nematic (TN) type, or of in Plane Switching (IPS) type etc., which are not discussed here in detail.

An embodiment of the present disclosure provides a three-dimensional display system, comprising: a display device, and a barrier located at the light emergent side of the display device. Addition of the distance adjusting structure, which adjusts the viewing distance of the three-dimensional display system by adjusting the distance between the display device and the barrier, between the display device and the barrier allows the three-dimensional display system free from limitation of a fixed viewing distance, thus resulting in a stronger spatially adapting capability and a broader application scope thereof.

Clearly, various modifications and variations can be made to the embodiments of the present disclosure without departing from the spirit and scope of the present disclosure. Thus, if these modifications and variations belong to the scope of the appended claims and the equivalents thereof, the present disclosure is intended to include these modifications and variations.

The invention claimed is:

1. A three-dimensional display system, comprising:

a display device;

a barrier located at the light emergent side of the display device; and

a distance adjusting structure arranged between the display device and the barrier;

wherein the distance adjusting structure is used to adjust the viewing distance of the three-dimensional display system by adjusting the distance between the display device and the barrier;

wherein the display device consists of a display region and a boundary-closed non-display region encompassing the display region; and

wherein the distance adjusting structure comprises at least one hollow cavity arranged at the non-display region, the volume of the hollow cavity being capable of being increased or decreased accordingly by inputting or outputting gas or liquid to/from the hollow cavity, the at least one hollow cavity comprising multiple hollow cavities that are arranged uniformly at the non-display region.

2. The three-dimensional display system according to claim **1**, wherein the hollow cavity is a loop cavity encompassing the display region.

3. The three-dimensional display system according to claim **1**, wherein the distance adjusting structure further comprises:

at least one pair of an inlet and an outlet arranged on the wall of the hollow cavity,

an input pressure pump connected with the inlet,

an output pressure pump connected with the outlet,

an input valve arranged between the inlet and the input pressure pump, and

an output valve arranged between the outlet and the output pressure pump.

4. The three-dimensional display system according to claim **3**, wherein the input pressure pump and the output pressure pump are integrated into one pressure pump.

5. The three-dimensional display system according to claim **3**, wherein the input pressure pump and the output pressure pump are two separate pressure pumps.

6. The three-dimensional display system according to claim **3**, wherein in the hollow cavity, every neighboring two pairs of the inlets and the outlets are equally spaced.

7. The three-dimensional display system according to claim **3**, wherein the distance adjusting structure further comprises:

a first flow controller arranged between the inlet and the input valve or between the input valve and the input pressure pump; and

a second flow controller arranged between the outlet and the output valve or between the output valve and the output pressure pump.

8. The three-dimensional display system according to claim **1**, wherein the amount of increase or decrease in the volume of the hollow cavity is calculated in real time or obtained by looking up a lookup table.

9. The three-dimensional display system according to claim **1**, wherein the barrier is a slit barrier or a liquid crystal barrier.

10. The three-dimensional display system according to claim **1**, wherein the display device is a liquid crystal display device or an organic electroluminescence display device.

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